# Discrete Time State-Space Aeroservoelastic Modeling using FUN3D, Phase I

Completed Technology Project (2018 - 2019)

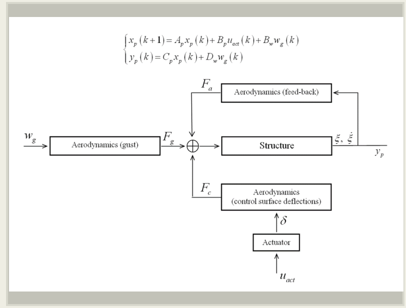
## Project Introduction

CFD-based reduced order modeling (ROM) has been an active research area, as they can be used directly with common linear flutter analysis tools. Among them, linearized reduced-order modeling approaches rely on linearization of the nonlinear unsteady aerodynamic flow equations, assuming that the amplitude of the unsteady motion is limited to small perturbations about the nonlinear steady-state flow condition. Various approaches of linearized ROMs, such as Auto-Regressive-Moving-Average (ARMA), first order Volterra Kernel, Impulse Response method, etc., can be broadly found in literature. However, few of them are geared towards the controller design oriented plant modeling, i.e., to obtain a plant model with control surface actuator modeling and gust excitations, and various types of sensor definitions including sectional/component load monitoring capability. In light of this, ZONA proposes to develop a discrete time state-space aeroservoelastic modeling technique with component load monitoring using NASA developed high fidelity Navier-Stokes flow solver, FUN3D. The subspace realization algorithm will be utilized to identify the individual aerodynamic systems, i.e., due to the structural deformations (modal coordinates), control surface deflections and discrete gust, respectively. The dataset needed for the aerodynamic system identifications are obtained by a wrapper program, called OVERFUN, driving the underlying FUN3D solver. OVERFUN's trim or static aeroelastic analysis solution will provide an initial background solution accounting for static aeroelastic effects. This unique initial flow solution sets the proposed efforts apart from other research work where an initial flow around rigid configurations is normally assumed. Once all three sub aerodynamic system are identified, they are coupled with the structural equation of motion represented in modal space and actuator models to yield the conventional state-space forms of aeroelastic model and plant model.

## Anticipated Benefits

The proposed effort is highly relevant to on-going and future NASA fixed wing projects, which involve innovative design concepts such as the Truss-Braced Wing, Blended Wing Body, and Supersonic Business Jet. The proposed work will offer a computational tool to the NASA designers for early exploration of design concepts that exploit the trade-off between the passive and active approaches for mitigating the potential aeroelastic problems associated with those configurations.

The proposed discrete time state-space ASE plant model generation can be applied to many categories of flight vehicles including blended wing-bodies, joined wings, sub/supersonic transports, morphing aircraft, space planes, reusable launch vehicles, and similar revolutionary concepts pursued. Hence, the proposed research and its outcomes will be highly needed for designing the next generation of civil as well as military aircraft to meet the stringent future performance goals.

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Small Business Innovation Research/Small Business Tech Transfer

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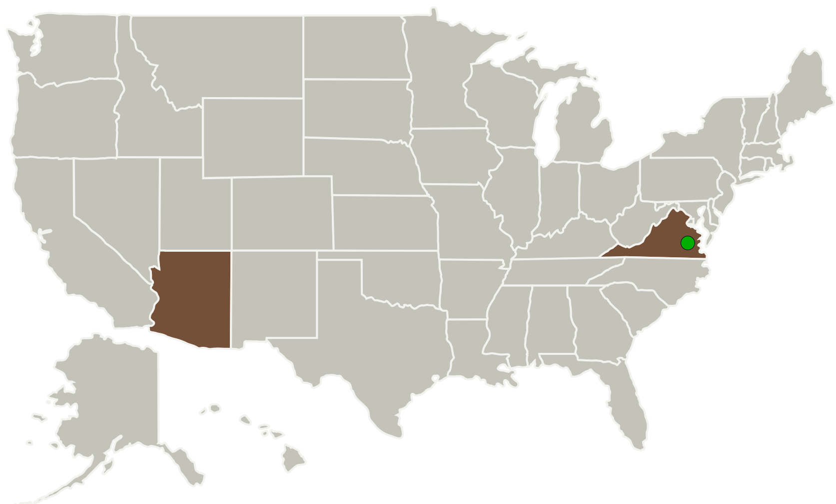
## Primary U.S. Work Locations and Key Partners



| Organizations Performing Work | Role | Type | Location |
|---|---|---|---|
| ZONA Technology, Inc. | Lead Organization | Industry<br>Small Disadvantaged Business (SDB) | Scottsdale, Arizona |
| Langley Research Center(LaRC) | Supporting Organization | NASA Center | Hampton, Virginia |

| Primary U.S. Work Locations | |
|---|---|
| Arizona | Virginia |

## Project Transitions

**July 2018:** Project Start

## Organizational Responsibility

**Responsible Mission Directorate:**

Space Technology Mission Directorate (STMD)

**Lead Organization:**

ZONA Technology, Inc.

**Responsible Program:**

Small Business Innovation Research/Small Business Tech Transfer

## Project Management

**Program Director:**

Jason L Kessler

**Program Manager:**

Carlos Torrez

**Principal Investigator:**

Darius Sarhaddi

**Co-Investigator:**

Darius Sarhaddi

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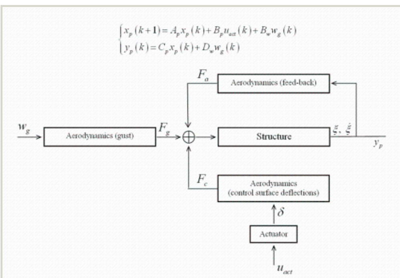
**February 2019:** Closed out

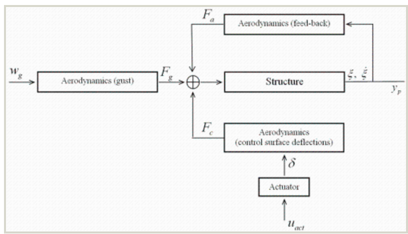
**Closeout Documentation:**

- Final Summary Chart*(https://techport.nasa.gov/file/141015)*

## Images




**Briefing Chart Image**
Discrete Time State-Space Aeroservoelastic Modeling using FUN3D, Phase I
*(https://techport.nasa.gov/image/128636)*




**Final Summary Chart Image**
Discrete Time State-Space Aeroservoelastic Modeling using FUN3D, Phase I
*(https://techport.nasa.gov/image/133434)*

## Technology Maturity (TRL)

Start: **2**
Current: **4**
Estimated End: **4**

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| Applied Research | | | Development | | | Demo & Test | | |

## Technology Areas

**Primary:**

- TX11 Software, Modeling, Simulation, and Information Processing
  - └ TX11.4 Information Processing
    - └ TX11.4.4 Collaborative Science and Engineering

## Target Destination

Earth